NPOESS Product Quality Flag Architecture

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ABSTRACT

This poster describes the general architecture and implementation of quality flags for the NPOESS data products. The National Polar-Orbitin Environmental Satellite System's mission is to build the next generation of weather satellites and to provide data to its users. Data from 11 instruments are delivered to the ground system where products are created in near real-time within 20 minutes of reception. Raw Data Records (RDRs) (e.g. electron counts, gains, or spectral information) are converted to Sensor Data Records (SDRs) using sensor specific calibration information to create Top of Atmosphere reflectances, emissivities, or interferograms. These SDRs are converted to Environmental Data Records, which are measurements directly made from atmospheric physics or inferred using behavior modeled by radiativ transfer models. These EDRs are divided into horizontal and vertical reporting intervals according to specified requirements, taking into account each sensor's physics. Cells are then aggregrated into data granules sized uniquely for each sensor. Types of quality reporting at the Cell and Granule level include range error flags, data processing and scene condition flags, as well as exclusion and degradation flags. Additionally, the use of supporting data for these measurements, including ephemeris ancillary data (e.g. climatology), is indicated at the Granule Level.

I. Introduction

The term "Quality Flag" refers to product flags that communicate the quality of a data product, the scene conditions present in the sensor Field of View (FOW), as well as what branches or algorithms were exercised Given the large swath width of several NPOESS sensors, this information is unique for each horizontal cel. Additionally, summary statistics on a subset of quality flags is planned to be available in the granule metadata. Figure 1 illustrates these levels of information, and where the reporting of such information is appropriate.

In developing a systems design baseline for the NPP quality flags, eight factors are considered: (1) The baseline quality flags for science algorithms as delivered by the algorithm vendors, (2) The customers' utility for each of the flags, (3) What information is needed to support calibration and validation activities, (4) Scene conditions allowing relaxation of performance conditions, (5) The purpose served by each flag in the Science Code (Informational or Processing), (6) The RDR quality, as indicated by the SDR values, and (7) Aggregation methods for quality information, e.g. along instrument scan lines or for entire granules of information, and (8) Implications of additional storage volume for the delivered products and associated flags.

II. System Description

The processing of the Raw Data Records (RDRs), Sensor Data Records (SDRs), and Environmental Data Records (EDRs) occurs in the Processing subsystem of the Interface Data Processor (IDP) of the NPOESS ground system. The IDP is comprised of six subsystems: Ingest, Data Management, Infrastructure, Processing, Data Delivery, and Data Quality Management and is located in each of four Central locations for NOAA, AFWA, the Navy, and NASA. Quality flags and metadata are set during processing of SDRs and EDRs.

III. Classes of Quality Flags

Quality Flags have been categorized into the following four Classes in order to distinguish purpose and function:

Class 1: Raw Data Record (RDR) Quality Flags
Class 2: Sensor Data Record (SDR) Quality Flags
Class 3: Environmental Data Record (EDR) Quality Flags
Class 3a: Processing Quality Flags
Class 3b: Scene Conditions for Performance Degradation Quality Flags
Class 3c: Performance Exclusion Quality Flags
Class 3d: Quality Monitoring Quality Flags
Class 4: Metadata
Class 4a: Graceful Degradation with Alternate Ancillary Data Sources
Class 4b: General Granule Quality derived from SDR Quality Information

Class 1: RDR Quality Flags
This class of quality flags is designated for possible future use. They are part of the RDR and are designed so that ground processing can verify that data recorded onboard are identical to data received at the ground. During initial sensor RDR to verified VIIRS RDR ground processing, checksums are recomputed and verified. If verification is unsuccessful an error message is written to a processing log and quality flags associate with the affected pixels are set. Any missing data discovered during this initial RDR processing results in the quality flag for the missing pixels to be set and the raw data to be assigned a fill value. Both the raw digital numbers (or fill) data and the pixel quality information are written to the verified RDR files for use during subsequent SDR production.

Class 2: SDR Quality Flags
This class of quality flags is calculated during the SDR production. The EDR algorithms use these data quality flags as part of their input data selection logic, particularly in checking quality of sensor data. Quality information includes tagging out of range values,

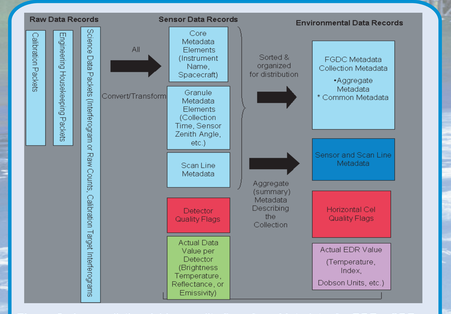

Figure 2. Image distinguishing quality flags from Metadata, for RDRs, SDRs, and EDRs with path of Application Packets to RDRs to SDRs to EDRs. All data is delivered in HDF format.

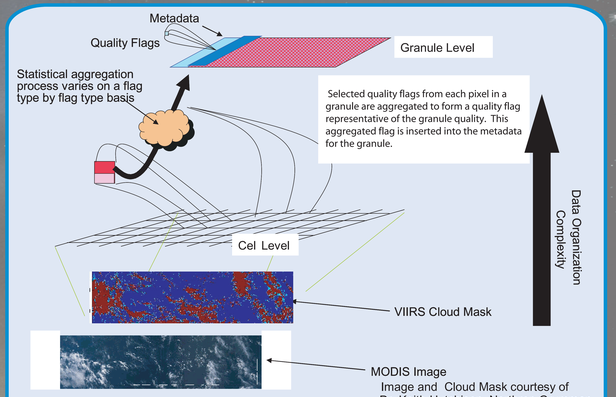

Figure 1. Derivation of Quality Flag Classes from pixel, or horizontal cell, to granule level. Example shown is for VIIRS Cloud Mask.

Class 3 EDR Quality Flags
Class 3 quality flags provide several purposes for the system, including:

Identify EDR confidence levels
Support error reporting
Trigger alternate data processing threads
Long term monitoring calibration/validation thresholds
Provide insight into the algorithm functionality

The list of the NPOESS EDR and IP quality flags is quite extensive and is given in reference 3. Each set of quality flags is tailored to each EDR and is generated by the science code. This class of quality flags can be divided into three subclasses, including: processing, scene degradation conditions, performance exclusions and quality monitoring.

Class 3a: EDR Processing Quality Flags
This class of quality flags is used for processing within an EDR and during subsequent EDR processing. During the generation of each EDR, the quality flags are calculated and stored at the cel level, and are informational or used by subsequent EDR processes to identify scene conditions used to trigger alternate algorithm branches. The current science code architecture outputs the quality flags in the EDR format. In some cases, quality flags of predecessor EDRs are incorporated in the EDR output format. An example of this class of quality flag is the Land/Water Background flag used by the Surface Temperature IP to trigger downstream processing for the Land Surface Temperature EDR or Sea Surface Temperature EDR.

Class 3b: Scene Condition Quality Flags
These flags test for Scene Conditions resulting in the relaxation of EDR performance requirements. These conditions are tested on a pixel-by-pixel basis and are reported with EDR value for each pixel.

Class 3c: Performance Exclusion Quality Flags
This class of quality flags is used by Data Quality Monitoring Subsystem to identify those data elements that were collected during periods when then algorithms are anticipated to yield poor or erroneous results. The Data Delivery and Data Quality Monitoring Subsystems may choose to ignore these flags using threshold values for the percentage of a granule affected The Data Quality Monitoring Subsystem may us these flags to establish the need for calibration coefficient updates.

An example of this class of quality flag is the condition where Aerosol Optical Thickness exceeds the value of 1.0, indicating that the FOV is obscured.

Class 3d: Quality Monitoring Quality Flags
This class of quality flags is used for alerting the Data Quality Monitoring Subsystem that the products being produced have quality parameters below a threshold value. Such alerts could be used to identify products or sensors that require updated calibration coefficients.

An example of this class of quality flag is the Cloud Confidence flag used by the Aerosol Optical Thickness IP.

Class 4: Metadata Quality Flags
This class of quality flags is used for identifying the average quality of a granule or the use of alternative ancillary data to calculate EDR values. These quality flags represent the general quality of the whole data granule calculated on the basis of compiled statistics on the quality flags at the cel level.

Class 4a Graceful Degradation with Alternate Ancillary Data Sources
The granule level metadata indicates the cases where Alternate Ancillary Data Sources (e.g. climatology in stead of numerical weather forecast fields) are used for EDR input.

Class 4b General Granule Quality
This class of quality flags is used for triggering the use of Alternate Ancillary data inputs for the processing of an EDR. In the processing flow of EDR calculations, decision points maybe incorporated to allow the substitution of alternate data sources in place of low quality predecessor EDR inputs. These flags are aggregated as a percentage of pixels within the granule affected by poor conditions.

An example of this class of quality flag is the Cloud Detection Result & Confidence Indicator flag used by the Sea Surface Temperature EDR.

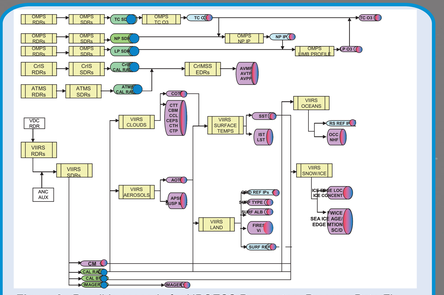

Figure 3. Possible scenario for NPOESS Preparatory Program Data Flow. Processes are shown in yellow, SDRs (green) have sensor specific quality flags (blue), and EDRs (purple) have quality flags and the horizontal cel level, and will possibly carry sensor quality data in metadata (blue).

LEGEND (Figure 3, above)

: Software Process
: Sensor Data Record (SDR)
: SDR Quality Flag Information (Class 2 Quality Flags)
: Environmental Data Record
: Intermediate Product
: EDR Quality Flag Information (Class 3 and 4 Quality Flags and

VIIRS
CM Cloud Mask
AOT Aerosol Optical Thickness
APSP Aerosol Particle Size Parameter
SUSP MTR Suspended Matter
CBH Cloud Base Height
CCL Cloud Cover/Layers
CTP Cloud Top Parameters
CTH Cloud Top Height
CTT Cloud Top Temperature
CEPS Cloud Effective Particle Size
COT Cloud Optical Thickness
SURF ALB Surface Albedo
SURF TYPE Surface Type
VI Vegetative Index
IMAGERY VIIRS Imagery
FIRES Active Fire
LST Land Surface Temperature
IST Ice Surface Temperature
SST Sea Surface Temperature
ICE EDGE LOC Ice Edge Location
ICE CONCENT Ice Edge Concentration
FWICE Fresh Water Ice
SEA ICE AGE Sea Ice Age
EDGE MTION Sea Ice Edge Motion
SC/D Snow Cover and Depth
CrIS & ATMS
AVMP Atmos. Vertical Moisture Profile
AVPP Atmos. Vertical Pressure Profile
AVMP Atmos. Vertical Moisture Profile
OMPS
TC Ozone Total Column
LP Ozone Limb Profile

IV. Common Aggregation of Quality Flags into Metadata

Statistics gathered over Class 2 and Class 3 flags at the cel may be summarized at the granule level metadata, as Class 4 Quality Flags. The EDR metadata statistics may include summary information regarding SDR quality used as data inputs for a unique EDR.

Common tools count existing quality flag status at the cel level, for either Input values and associated flags, or output values and associated flags. An example of Class 3 quality flags which may be reported at the metadata level are those found in the VIIRS Cloud Mask, listed below.

VIIRS Cloud Mask Quality Flags

Land/ water
Cloud Detection Result & Confidence Indicator
Cloud Mask IP Quality
Adjacent Pixel Cloud Confident Value
Non Cloud Obstruction (Heavy Aerosol)
Day/Night
Snow/Ice Surface
Sun Glint
Shadow Detected
Fire Detected
Non Cloud Obstruction (Heavy Aerosol)
Thin Cirrus (solar, RM9)
Thin Cirrus (IR, BTM15-BTM16)
IR Threshhold
High Cloud
IR Temperature Difference Test (BTM14 - BTM15 & BTM15 - BTM16)
Temperature Difference test (BTM15-BTM12)
Temperature Difference test (BTM12-BTM13)
Visible Reflectance Test (RM5)
Visible Reflectance Test (RM7)
Visible Ratio Test (RM7/RM5)
Cloud Phase
Imagery Resolution BTD Test
Cloud Imagery Resolution RI1 Test
Cloud Imagery Resolution RI2 Test
Conifer Boreal Forest
Spatial Uniformity Test

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